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CITY DOCUMENT.

[No. 118.

REPORT.

ON THE

WATER WORKS AND SEWERS,

IN THE

CITY OF PROVIDENCE,

PRESENTED TO THE BOARD OF ALDERMEN, NOVEMBER 2, 1874.



PROVIDENCE:

HAMMOND, ANGELL & CO., PRINTERS TO THE CITY.

1874



*Providence. Board of Aldermen. Special Committee
on water works and sewers.*

1873-74.]

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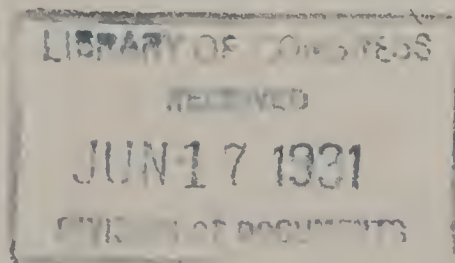
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RESOLUTION OF THE BOARD OF ALDERMEN, appointing a Special Committee
of Inquiry, in relation to, WATER WORKS AND SEWERS.

REPORT OF THE SPECIAL COMMITTEE of the Board of Aldermen.

REPORT OF THE BOARD OF WATER COMMISSIONERS.



RESOLUTION OF THE BOARD OF ALDERMEN.

[Passed October 12, 1874]

RESOLVED, That Aldermen Fisher, Spicer and Clarke, be and they are hereby appointed a committee to inquire into and report to this board, as soon as practicable, upon the following matters, connected with the introduction of water into this city, and the construction of sewers, to wit:

The actual cost of the water works, and their capacity at date of last quarterly report, as compared with the original estimates and plans,—meaning that the whole amount of expenditures, according to said quarterly report, shall be so classified as to give the exact cost of each division of the works, including in such classification the cost of lands and water privileges, and separating maintenance from construction: the original estimates for the work to be classified in the same manner, so that a comparison may be made between them.

The revenue, thus far, from water, as compared with the revenue from same number of miles of pipe in other cities and at the same stage of construction.

The probable length of time that will elapse before it will be necessary to erect a second engine at Pettaconset pumping station.

The cost of the stand pipe to be erected at the Pettaconset engine-house in connection with the Cornish engine now under contract; and whether it will also serve for any additional engines that may be erected there.

The cost of the stand pipe at the Hope engine-house, if one has been erected there, or, if not, whether one will be required for the second engine recently contracted for, and if so, its probable cost.

What amount has been paid for marble used in construction, and where located, and what sums have been expended for foreign granite, and where it was obtained.

The number of the employés in the engineering department, and the capacities in which they severally act, with the rate of yearly compensation of each.

The accessibility of all contracts and records in the office of the board of water commissioners, to any citizen who may desire to examine them.

The comparative merits and cost of Scotch and other pipes, and the proportion of our sewers constructed of pipes of Scotch manufacture.

The depths and sizes of our sewers, as compared with those of the larger cities of this country.

The depths of our sewer outlets, with reference to the tides ; and the cases of damage, if any, resulting from the overflow of tide water from the sewers into the basements of buildings ; and, if any, the cause of such damage and the proper remedy therefor.

The amount of deposit in the sewers since their acceptance by the city, stating particularly the amount in that portion of the sewers flowed by tide water.

The method employed for cleaning the sewers, and to what extent such cleaning is necessary.

The condition and capacity of the stone sewers taken up, their total length, with the sizes and kinds of sewers substituted therefor.

Whether any sewers have been constructed which were not ordered by the city council, and if so, where located, and the reasons for such construction.

The kind of pipe which parties connecting with sewers are required to use.

*REPORT OF THE COMMITTEE OF THE BOARD
OF ALDERMEN.*

[Presented November 2, 1874.]

TO THE HONORABLE, THE BOARD OF ALDERMEN OF THE
CITY OF PROVIDENCE :

The committee appointed October 12th, 1874, to report to this board upon various matters connected with the introduction of water into this city and the construction of sewers, respectfully beg leave to present this their report :

The inquiries under the resolution were so many and included, as they did, those most important, bearing upon both the introduction of water and the construction of sewers, that the committee almost shrank from the duty imposed upon them. But they felt that matters of great importance were involved, concerning which the tax payers and citizens generally had a right to be informed.

It is obvious that for the information sought in the resolution, the committee must depend in a great measure upon the records in the office of the water commissioners, and from the water commissioners and chief engineer themselves. The committee waited upon the water commissioners, and were courteously received, and at three long interviews at their office, every facility was afforded to throw light upon every inquiry in the resolution. The committee were allowed free and full access to all the books of account and records in that office, and were aided by Mr. C. D. Sellew, the secretary, in the examination.

At the first meeting of the committee with the water commissioners and chief engineer, the resolution under

which the committee were acting, was presented to them, and after a very free, full and lengthy interview as to what the resolution comprehended, the committee requested them to submit a report in writing, at their earliest convenience, touching all the matters of which we desired information. With creditable promptness, they submitted to the committee their answers to all the inquiries. We submit herewith their answers as received by the committee, which are full and complete. Most of these answers may receive confirmation from their quarterly reports, submitted to the city council at various times.

As to the practicability of some things connected with the construction of both the water works and sewers, there may be a difference of opinion among practical minds. The facts the committee have obtained can be fully substantiated by the records in the office of the commissioners, and the works, both water and sewer, as they stand partially constructed to-day.

The committee do not wish to lengthen out their report by a repetition of what is in the report of the water commissioners to the committee. But they earnestly ask the board to read and examine carefully all the facts and figures in the report of the commissioners, in order that they may be able to form an intelligent opinion concerning matters bearing upon the construction of the most important works in which this city ever has been or ever will be engaged. It may be well for the committee to notice some of the important items contained in the commissioners' communication. It will be seen that the original estimate of the cost of the water works was four millions four hundred and seventy-seven thousand thirty-five dollars and eight cents (\$4,477,035 08), and that the original plan has been very much changed, materially enlarged and improved. It is expected that it will be completed by the next summer, so far as to pass from the hands of the water commissioners to the city.

The whole cost of construction to September 1st, 1874, was three millions four hundred fifty-seven thousand four hundred forty-four dollars and seventy-nine cents (\$3,457,444 79), or one

million nineteen thousand five hundred and ninety dollars and twenty-nine cents (\$1,019,590 29) less than the original estimate. This, as will be seen, is after deducting the cost of maintenance from Jan. 1, 1872, to September 1, 1874, which was eighty-one thousand six hundred fifty dollars and seventy-four cents (\$81,650 74).

It will be noticed that the water works were commenced May 4, 1870, and that water was introduced December 1, 1871—one year and seven months. From the latter date a revenue commenced to the city at a time when only one million four hundred and ninety-four thousand three hundred thirteen dollars and ten cents, (\$1,494,313 10) had been expended. The revenue the first year was \$41,003 51, or about two and three quarters per cent. on the cost to that time. The second year, the income was \$97,386 09. The third year, estimating the last four months at the ratio of the first eight months, it was \$145,551 68, or total to Dec. 1, 1874, \$283,941 28, or eight and one-fifth per cent. on the cost to Sept. 1, 1874.

These figures, we think, will be satisfactory to the citizens of Providence, and are certainly creditable to the water commissioners and their chief engineer, as showing the perfection of the work when only partially constructed, and their entire willingness that the water should be let on, that the city might earlier derive an income therefrom. It is unusual and almost entirely without precedent, that works of this kind are opened to public use until completed. This certainly showed a confidence in their work, as far as it had gone, and experience has since proved the correctness of that confidence.

The committee have nothing but commendation to offer in regard to the manner in which a large portion of the work of introducing water into the city has been done. The great care which has been taken in regard to the manufacture of the iron pipe, so that it should be of uniform quality, thickness and durability, has doubtless rendered this portion of the work superior to that of any other city in the United States. And when it is remembered that the cost of the iron pipes in which

the water is brought from the reservoir and conducted through the streets, including the cost of laying them, constitutes fully one-half of the whole expense of the water works ; and when we reflect that these pipes are all laid several feet under ground, and therefore difficult of access and expensive to repair, it will at once be conceded that too much care could hardly be given to their proper manufacture, and that no expense was unnecessary which would insure a perfect and durable pipe.

In the building of the reservoirs, also, so far as your committee are able to judge, the work seems to have been substantially and thoroughly done, and there can scarcely be a question as to their durability.

The water-works for the supply of any city where the necessity exists of raising water to a certain height and storing it for distribution, may be divided into three general divisions. First, the reservoirs into which the water is to be raised and stored. Second, the system of pipes or conduits through which the water is to be distributed for use ; and, third, the pumping apparatus for forcing the water to the required height. The first and second of these general divisions are necessarily required to be, and it is doubtless the best economy that they should be, of as permanent and durable a character as the experience and science of the present day can devise and build. In these two divisions, as has already been stated, your committee take great pleasure in commending the work done as alike creditable to the city and honorable to the commissioners and engineer who have planned and executed it. In regard to the third division, namely, the pumping system for raising and forcing the water from the river into the reservoir, your committee gladly and willingly concede that the water commissioners and the chief engineer, in providing the very costly apparatus which is now in process of erection at the pumping station at Pettaconset, have acted with the same regard as to what they believe to be for the best interests of the city, as in those portions of the work already spoken of ; yet your committee feel obliged to differ radically with the

commissioners as to the necessity of so large an outlay. The cost of the Pettaconset pumping station, now in process of erection for the Cornish engine, including pump, well, foundations, and all essential requirements for the same, to September 1st last, as furnished us by the commissioners, was two hundred and seventeen thousand seven hundred and forty-five dollars, sixty-two cents (\$217,745.62); their estimated amount to complete same, seventy-seven thousand four hundred and fifty dollars (\$77,450); Cornish engine, delivered and set up, per contract, one hundred and six thousand dollars (\$106,000); tools and extra prices for same, \$14,000; rough pieces for same, to be furnished for same by commissioners, seven thousand six hundred and thirty-seven dollars and forty cents (\$7,637.40); stand-pipe, per contract, to be set up by contractor, twelve thousand dollars (\$12,000); amount expended on natural filter basin, \$33,594.50; thus making the total cost of the pumping apparatus connected with and including the Cornish engine, \$468,427.52.

This sum is the amount actually paid or to be paid for this purpose, without reckoning anything which would be properly chargeable to this department of the works for its proportion of salaries, engineering and miscellaneous expenses. If this were added, it would make the cost of the pumping department of the water works in round numbers, very nearly a half million of dollars. This plan also requires for its completion an additional Cornish engine, which would add at least one hundred thousand dollars more to the cost of this department of the service. The Worthington engine, now in operation at Pettaconset, cost, including all repairs up to September 1st, 1874, \$41,452.38. The building in which it is placed, cost \$9,718.09. This engine takes the water directly from the river, and has for three years past, supplied the city with all the water it has used. It has not run, on an average, six full days in a week, and that the supply of water has been abundant, is a fact patent to every citizen. If this engine should be run day and night it would furnish about

double the quantity of water which is now daily used for all purposes, including, of course, the fire supply.

It would not, however, answer to depend upon one engine for continual service, as there must occasionally be stoppages for repairs, and breakages are liable to occur. If another Worthington engine of the same cost and capacity as the one now in use, were placed at the pumping station, the city would have, without any doubt whatever, sufficient pumping power to supply itself abundantly with all the water needed for ten or fifteen years to come. The simple interest upon the money which has been and will be expended upon the completion of the pumping station at Pettaconset, including engines, stand-pipe, chimney, and all appurtenances belonging to this department of the service, would suffice to build a new Worthington engine, of same capacity as the one now in use, once in every two years. The city would also have the advantage, by taking the course above indicated, of being in a position to avail itself at any time during the coming ten or fifteen years, and at a little comparative loss and without the slightest danger to the water service, of any improvement in pumping engines which the inventive genius of the country might produce. Whereas, the course taken by the water commissioners in this matter, precludes the city almost entirely, unless at an immense loss, from making any change or adopting any improvement in the very department of the water works where improvement may be most desirable, and is most likely to occur. For these and other reasons which will readily suggest themselves, your committee cannot agree with the water commissioners in their view of the necessity of spending so large an amount in the pumping department at Pettaconset.

We ask your particular attention as to what the commissioners say in regard to the comparative merit and cost of Scotch and other pipes. We think their testimony and that of others, from which they quote at some length, establishes the wisdom of putting the best pipe into our deep sewers, inasmuch as the difference in the first cost of the pipe is small compared with the whole cost of the sewers or that of taking

up the sewers or any portion of them, in consequence of imperfect pipe, and from disintegration from any cause, after being laid.

The committee are of the opinion that to put other pipe than that known to be durable for a long period, into sewers, would be a mistaken policy, as it would be more costly in the end, besides the great inconvenience it would cause those who use the sewers, should they give out.

The committee saw various kinds of pipe subjected to a strong test by being immersed in acid. Some would stand the test perfectly, and others would commence dissolving at once. Where only fresh water is to pass, the kind of pipe is not of so much consequence. But inasmuch as no rule or ordinance can prevent any and all substances, at times, being introduced into our sewers, it would be bad economy to put in any pipe which would not be impervious to any substances which might go into them from our chemical works, print works and other manufactories.

The committee had before them Mr. Tripp, a manufacturer of drain pipe, etc., in this city. He was given a patient hearing, and produced letters and reports from various parties and cities who are using cement pipe with satisfactory results, and still continue its use. The committee do not doubt that, for most purposes, where only ordinary substances are to enter, that it will answer well, and should recommend it for private and public use in such cases. But to introduce it into our deep sewers, the committee would consider it inexpedient and unwise. You will bear in mind that as no chain is stronger than its weakest link, so no sewer is secure with any portion being laid with imperfect or doubtful pipe.

As to the depths and sizes of our sewers, the committee, in addition to the written report of the water commissioners to them concerning these points, heard the commissioners and chief engineer fully in regard to all matters bearing upon them. And we are of the opinion, that in the main, the plans they have pursued in laying them, are correct, and for the present and future interests of our growing city. We recom

mend to the board particularly, that portion of their report touching these matters and all others connected with the subject of sewers, as being full and intelligent, together with facts concerning sewers in other cities.

The commissioners personally showed every desire to convey to the committee a full understanding of what they are, and have been doing. We were more than pleased by the apparent perfect system by which their accounts and records are kept, and by their arrangements for careful inspection of all material used in the construction of the water works and sewers, and the great care they were taking to check everything from entering in at variance with the city's real interest, and the perfecting of the great work in which they are acting as the city's agents.

In great public works of this kind, it is true economy to arrive as near perfection in their construction as possible. These works are intended to last for all time, resulting in untold blessings to the latest posterity and promoting the growth and prosperity of our city. When they shall be completed, we shall not be ashamed to compare them with those of any other American city.

It is not sufficient that our water works should be constructed only to supply a city twice or thrice the size of ours at present. Inasmuch as we anticipate a great future, we should plan in the beginning for such, in the quantity of water as well as reservoirs, engines, engine-houses and main pipes, so as to answer for this growth. There are some things connected with the construction for which we can wait until the growth of the city demands it.

But these main things ought to be provided at the outset. We believe it is the desire, above all others, of the water commissioners to pass over to this city, so far as they go, a complete and thorough work. They believe this to be for the best interests of the city and true economy, and to this end they are diligently and faithfully working. The particular examination of every material entering into the construction of the water works and sewers, requires, of course, intelligent

service and increase of help, which adds to the cost. But it is all saved and more, to the city, by the rejection of imperfect material. . Nothing is intended to go into the works, that has not passed the ordeal of a thorough inspection. The committee are not inclined to lengthen their report, inasmuch as the answers of the water commissioners are so full and complete. Perhaps they need not say more, but could not say less. In closing, we ask the board and the public generally to examine carefully the facts brought to light by this resolution. It would be wonderful if some errors have not been committed in so large an undertaking. If there have been, and they can now be remedied, let them be stayed; but before condemnation, let all be carefully considered and examined, in order that we may form an enlightened judgment. To aid such judgment has been the only object of this examination and this report, which we now most respectfully submit.

ADDISON Q. FISHER,	} Committee.
GEORGE T. SPICER,	
GEO. L. CLARKE,	

*COMMUNICATION FROM THE BOARD OF WATER
COMMISSIONERS.*

OFFICE OF THE BOARD OF WATER COMMISSIONERS, }
PROVIDENCE, R. I., October 30, 1874. }

MESSRS. ADDISON Q. FISHER, GEORGE T. SPICER, GEORGE
L. CLARKE, COMMITTEE OF THE BOARD OF ALDERMEN:

Gentlemen: In answer to your request for information in
regard to the matters mentioned in a resolution of the Board
of Aldermen, passed October 12th instant, in relation to
water works and sewers, the Water Commissioners respectfully
report:

First: As to "*the actual cost of the water works and their
capacity, at date of last quarterly report,*" etc.:

The original estimate of the cost of the introduction of water by the Pawtuxet plan (one of four reported to the City Council in October, 1868, by the Joint Special Committee of that body) was.....	\$4,477,035 08
The actual cost of land and land and water damages, construc- tion and maintenance, to September 1, 1874, as shown by the Commissioners' Trial Balance of Ledger (City Document No. 103, current series, page 29), was:	
Amount of approved bills.....	\$3,696,126 47
Amount to the credit of J. B. & J. M. Cornell.....	1,000 00
Amount to the credit of Warren Foundry and Ma- chine Co.,....	4,195 00
Amount to the credit of Gloucester Iron Works....	7,490 47
Amount to the credit of Interest.....	54 66
Total	\$3,708,866 60
Less the amount received for rent of property pur- chased, sale of buildings, wood, meters, and other material, etc. (excepting receipts for water and \$186 received for penalties)	\$138,003 52
The estimated cost of maintenance from January 1, 1872, to September 1, 1874, was	81,650 74
	<u>\$3,489,212 34</u>

Deduct estimated amount due water works from sewer department for engineering and office expenses.....	30,600 00
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\$3,458,612 34

The following items, which will be collected, should be deducted from the cost of the works:

City of Providence, Abbott Park Fountain.....	\$708 74	
City of Providence, Public Market	12 00	
Heirs of Joseph Harris, for work on Reservoir avenue	446 81	1,167 55

Cost of construction to September 1, 1874.....	\$3,457,444 79
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Which includes \$226,371.75 paid for land and land and water damages. There is due from A. & W. Sprague Manufacturing Company the sum of \$2,500, which said Company, by written agreement, agreed to pay towards the cost of grading a road in which leading mains are laid, which amount, if eventually collected, should be deducted from the cost of construction.

The plans upon which the works have been constructed are so much changed from those originally estimated upon, that no fair comparison of items can be made between them. The general effect of these changes has been to materially lessen the cost of iron mains and distribution, and to increase the cost of the pumping works. It is believed that each change has increased the value and efficiency of the works, except in the matter of filter-beds. The following comparison is intended to answer the requirements of the resolution, so far as practicable:

LANDS AND DAMAGES.

The original estimates for lands were made by the aforesaid committee and included only such areas and rights of way as would be needed for the permanent use of the works. In negotiating for lands, the Water Commissioners found it desirable to buy whole farms, in some cases, rather than to "take" only such portions as were needed. This was true also of water damages, and the entire privilege at Pawtuxet was bought. It thus happens that while the payments for lands and damages have been large, the city has valuable

real estate and water power that may be sold without injury to the works. The lands which may be sold have very largely increased in value since their purchase. Another cause for the increase under this item was the construction of Hope Reservoir, which required the expenditure for lands of more than half the total amount charged to this account. The whole cost, however, of land and construction for Hope Reservoir is to be balanced against the saving in cost of iron mains and distribution thereby secured.

Original estimate for lands and damages... .. \$52,550 00

COST.

Hope Reservoir, for land (net).	\$118,229 65
Sockanosset Reservoir, for land (net)... ..	14,539 86
Line of leading mains, for land and damages.....	1,665 00
Force main line, for land and damages.....	3,006 35
Real Estate in Warwick (net).....	11,986 80
Water privileges, mill and other real estate in Pawtuxet (net)...	46,392 43
Pettaconset Pumping Station, for land (net)	25,899 38
Fences and sundries.....	4,652 28

\$226,371 75

Excess of expenditures to September 1, 1874..... 173,821 75

PUMPING WORKS AT PETTACONSET.

A change of plan in Sockanosset Reservoir—by which, on account of the substitution of a filtering-basin at Pettaconset in place of filter-beds at Sockanosset, a saving of over two hundred thousand dollars was secured, with higher head and greater capacity in the reservoir—involved a change of plan and largely increased cost at the Pettaconset pumping station. A further increase in cost was incurred for the purpose of securing safe and efficient engines of a high duty, by which it is expected that the yearly expenses will be lessened, resulting in greatly increased economy.

Early in the consideration of the plans by the Water Commissioners, the question of the best method of filtering the water was earnestly discussed. The artificial beds which were planned would be expensive and require constant attention in maintenance, while careful borings at Pettaconset indicated “the probability of obtaining a sufficient quantity of clear

water from basins excavated in the sand at a depth below the surface of the river at a comparatively small expense, and without permanent clogging." The commissioners finally determined to try the natural filter basin at Pettaconset, "notwithstanding the possible chance of failure in the scheme and the possible need of constructing the artificial filter-beds at last. Even, however, should it fail as a natural filter-basin, it would probably be worth a considerable portion of its cost as a settling-basin from which the water, in this case introduced into it by pipes running through the river embankment, would be pumped." The above quotations are from the report of the chief engineer made in January, 1871. It proved that the sand is finer than the borings indicated, and therefore the water runs through it less rapidly than was expected. Enough is probably received, however, for the present wants of the city, and a ready extension may be made by galleries on the Warwick side of the river at moderate expense. A pipe has already been laid through the river embankment, which will form part of a line of communication between the basin and such galleries, should such galleries be constructed.

The original estimate for dam and conduit, pump-well, engine-house and two engines at Pettaconset was	\$288,003 87
There has been expended for these purposes, including filter-basin, the sum of.....	395,423 97
Of which it is estimated that one hundred and forty-four thousand dollars have been expended for engine-house and boiler house above the pump-well and the engine house foundations.	
Excess of expenditures to September 1, 1874.....	\$107,420 10
. One engine has been in operation there nearly three years, and a second is expected to be running within six months.	

SOCKANOSSET RESERVOIR.

The original estimate for this reservoir with filter-beds was....	\$136,663 59
The amount expended was	233,437 91
Expenditure to September 1, 1874, less than estimate.....	\$203,225 68

The available water surface is six and a half feet higher than originally contemplated, and the available capacity is a little more than four million gallons greater.

HIGH SERVICE.

It was originally intended to erect a high-service reservoir of an available capacity of about one million gallons, near East Turnpike, opposite Doyle avenue, but as the head of water contemplated was much less than the commissioners thought necessary for the district, and an increase of head would be very expensive, a change of plan was determined upon, which would dispense with the reservoir and give the required head of water directly from the distribution. Under the present system water is maintained in the high service distribution under a pressure equal to a height of water about thirty-five feet above that originally planned. A reservoir has great value in furnishing a store of water to be drawn upon during hours of excessive demand, whether for fire purposes or for the largest requirements of the day service. If, therefore, a reservoir is dispensed with, the pumping power must be much larger than would otherwise be needed. The original estimates provided for two pumping engines of a capacity of one and a half million gallons each in twenty-four hours, while the present plan provides for two engines of a capacity of five million gallons each in the same time. Duplicate engines, each of the maximum capacity required, are considered to be essential in such a service, for the reason that one engine must inevitably be down for repairs, at times, and the maximum demand is as likely to occur at such a time as at any other. It is usual to estimate the discharge of a fire stream, under about one hundred and seventy-five feet head, at from two hundred to four hundred gallons per minute, depending on the size of nozzle and length of hose. At the test of fire hydrants in Market Square, in November, 1872, when twenty-four streams were played through nozzles from seven-eighths to one and one-fourth inch diameter, it was found that the discharge was probably a little over two hundred gallons per minute for each stream. A few of the hydrants in the High Service are under about twenty-five feet greater head than those on Market Square, and would therefore discharge more water through the same nozzle. At the same rate of dis-

charge as in Market Square, a five million engine will supply about seventeen fire streams, or if a discharge of three hundred gallons per minute is assumed, the engine would supply less than twelve fire streams, even assuming that all other use of water could be cut off during a fire, which is, of course, out of the question. If the head is allowed to run down on the engine, or hydrants located on higher ground are used, a greater number of streams of less force could be supplied. As the demand for water for ordinary service is proved to be, during some hours, about two and a half times greater than at others, it seems clear that after such supply is given, the remaining capacity of a five-million engine is not more than a prudent provision for fire purposes requires.

The original estimate for the high service, exclusive of mains and distribution, was.....	\$189,719 20
Expenditures	168,355 10
Expenditures to September 1, 1874, less than estimate.	\$21,364 10

DELIVERY OF WATER.

The changes in other parts of the works, which increased their cost, very materially lessened the cost of distribution, which originally formed more than three-quarters of the estimated cost of the entire works.

The most important change was the construction of Hope Reservoir, the practical effect of which was to obtain equal efficiency in the supply of water, with smaller pipes. The reservoir amounts to an enlargement of the pipes where it is located, so as to store a supply of water when the demand in the city is small, and give it out when the demand is large. The following extract, from a report of the chief engineer, made January, 1871, will illustrate its operation ;—" A leading main from a reservoir, at a distance of several miles on one side, is required to be of greater capacity, in order to supply the greatest demand without too much loss of head under that rate of flow ; but, with another reservoir lying beyond the centre of distribution, near at hand, on the opposite side a leading main may be of such size as to supply the *average* de-

mand ; for when the draft upon the main exceeds the average quantity, so as to lessen the head upon the pipes, a supply begins to flow from the regulating or storage reservoir, and thus the demand is supplied from both directions through pipes of a combined capacity, sufficient to maintain the required head. Again, when the draft becomes less than the average quantity, the head upon the pipes increases, and the water overflows into the regulating reservoir and is stored there for use during the greater demand." Smaller pipes may also be laid in the distribution, when there is a supply from two directions during great demand.

The original estimate for force mains, leading mains, upper service mains and distribution, was.....	\$3,385,098 42
Expenditures for mains, distribution and Hope Reservoir,.....	\$2,192,999 12
To this may be added the cost of service pipes, drink- ing fountains, &c., not originally estimated for..	86,969 80 2,279,998 62
Expenditures to Sept. 1, 1874, less than estimate....	\$1,105,129 50

ENGINEERING AND OFFICE EXPENSES.

The various changes on the works very largely increased the necessary engineering expenses, especially in the construction of Hope reservoir and the changes at Pettaconset. This is illustrated in the length of time the works have been under construction, being already nearly five years, while the works, as originally planned, might possibly have been completed in three years. But this increase of time has been of no disadvantage to the water-takers, who began to be supplied about two years after the works were commenced, which, considering the state of the works, is unprecedented, so far as known, except, perhaps, in the case of Brooklyn, where, however, the distribution had been, in great part completed before the water was supplied. The Commissioners have felt that in works of this character and magnitude, the most thorough and careful investigation was essential to a true economy, and they are satisfied that a saving of expense in this department would have resulted in manifold greater expenditures in other ways and in less valuable works.

The original estimate for engineering and office expenses, was....	\$125,000 00
The expenditures have been (net).....	141,104 36
	<hr/>
Excess of expenditures over estimate.....	\$ 16,104 36

ITEMS NOT ORIGINALLY ESTIMATED FOR.

Under this head are included :

Three dwelling houses for employes, at Pettaconset, costing.....	\$ 9,621 71
One for the keeper at Sockanosset, unfinished, costing thus far....	1,114 32
Three telegraph stations, with connecting lines, costing.....	1,887 99
Sundries	158 76
	<hr/>
Total.....	\$12,782 78

CAPACITY OF WORKS.

The works as constructed have to-day, in some respects, a capacity greater than those originally planned and in others less. In the most important item—that of distribution—the length of water mains laid, is nine and two tenths per cent. greater than at first contemplated, and pipes are on hand sufficient to make the length sixteen and eight-tenths per cent. greater.

The total length of mains and distribution originally estimated for, was.	95.85 miles
The total length laid to October 11th instant, was.....	104.68 miles.
The length of pipe on hand ready to lay, was.....	7.27 miles.
Laid and ready to lay.....	111.95 miles.

The capacity of the works to supply fire streams is very much greater than at first planned. Eight hundred and one fire hydrants had been set to October 11th inst., each having a delivering capacity more than four times as great as the hydrants at first estimated for, of which there were to have been six hundred and eighty-five.

The lands and water power, as before stated, are much in excess of the quantity estimated.

On the other hand it yet remains to complete the engine house and boiler house at Pettaconset; the engine and appurtenances to be erected therein; the Hope Reservoir and the second High-service engine; and to lay the second force main to Sockanosset.

The estimated cost of the work done since the last quarterly report, and to be incurred to lay the pipes now on hand, and the amount still due for pipes delivered, is.....	\$219,942 78
The expenditures necessary to bring all other departments up to the capacity originally planned are estimated at.....	487,422 31
	<hr/> \$707,365 09

Of this amount it is estimated that \$77,450 will be required for the engine house and boiler house at Pettaconset, making the total cost of those buildings above the pump-well and engine house foundations, about \$221,450.

The value of the work done, or included in the above estimated cost, in the departments of mains, distribution and fire supply, above that originally estimated, is estimated at...\$382,780 31

Add value of real estate and water power that may be sold.....	50,000 00
	<hr/> 432,780 31

Balance....	\$274,584 78
To be added to cost of works, as above.	3,457,441 79
	<hr/>

Making	\$3,732,029 57
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—which is the estimated cost of completed works of at least equal capacity and efficiency as originally estimated for, [at \$4,477,035 08,] except in the matter of filter-beds and the difference of capacity between the five million engine, first erected at Pettaconset and a nine million engine originally estimated for.

Second :—As to “ *the revenue, thus far, from water, as compared with the revenue from the same number of miles of pipe in other cities, and at the same stage of construction.*”

The Commissioners are not aware that any other city has supplied water generally to takers at the same stage of construction as in Providence. The only case that approaches it within their knowledge is that of Brooklyn, where the contractor, who was under obligations to supply water within a given time, put up a small engine and supplied water about thirteen months before the first permanent engine was ready to run ; the distribution was, however, nearly completed before he did so, and amounted in the next year, at the date of our first definite record, to about one hundred and twenty-four miles. We have no records for proper comparison of income, as the city did not take charge of the works until later.

Records of the works in New York, Boston and Providence enable us to make the following comparison :

	Work begun.	Water Introduced.	Amount expended at time of introduction.	Income.		
				First Year.	Second Year.	Third Year.
New York..	Spring, 1837.	Oct. 5, 1842.	\$12,500.000 00	\$32,053 74	\$84,444 68	\$117,277 86
Boston.....	Aug. 20, 1846.	Oct. 31, 1848.	3,998,051 83	71,657 79	99,025 45	161,052 85
Providence.	May 4, 1870.	Dec. 1, 1871.	1,494,313 10	41,003 51	97,386 09	145,551 68 (?)

The expenditures in Boston and Providence are less credits, which in the latter city, amounted to \$20,621 98. The first year's income in New York was for a supply during seven months. The income in Boston is independent of the public use. The third year's income in Providence is estimated as follows :

Amount collected in first eight months of 1873.....	\$72,144 22
Amount collected in last four months of 1873.....	25,241 87
	<hr/> \$97,386 09
The collections in last four months were 34.988 per cent. of the collections in the first eight months.	
Amount collected in first eight months of 1874	107,825 65
Estimate for last four months at 34.988 per cent. of first eight months.....	37,726 03
Estimated income for 1874.....	145,551 68
The actual income to the 21st instant, inclusive, was	122,005 05
The total amount of income from water rates at the date of the last quarterly report, was.....	246,215 25

It will be noticed that none of this amount is deducted from the cost of the works.

Third :—As to “*the probable length of time that will elapse before it will be necessary to erect a second engine at the Pettaconset Pumping Station.*”

The average daily consumption of water in this city at the present time is about two million gallons. It is not probable that a second *permanent* engine will be needed at Pettaconset, until the daily consumption reaches about five million gallons. The length of time that will elapse before such use, can only be conjectured ; perhaps it will be four or five years.

The works were planned for such use of water as other cities have proved to require, but the unprecedented employment of meters here has kept the use of water much less than it would otherwise have been.

Fourth :—As to “*the cost of the stand-pipe to be erected,*” &c.

A contract has been executed with the Rhode Island Locomotive Works for furnishing and erecting this stand-pipe for the sum of twelve thousand dollars. ~~the~~ Additional cost for casing and capping will not exceed two thousand dollars. The stand-pipe, (as also the pump-well, foundations and superstructure of engine-house and boiler-house,) will serve for four engines.

The introduction of such a feature as a stand-pipe in the building must necessarily affect the general design ; if any additional expenditure has been incurred on this account, it is included in the amount stated as the cost of engine house.

Fifth :—As to “*the cost of the stand-pipe at the Hope Engine House,*” etc.

No stand-pipe has been erected at Hope pumping station, and none will be required for the second engine for that station, now in process of construction.

Early in the work of constructing Hope Reservoir, and before the engine now running at this station was erected, the commissioners endeavored to obtain from the contractor for the first Hope Engine a release of his right to claim the erection of a stand-pipe at that point, for the reason that they believed it unnecessary and wished to save the expense ; but failing in this, as will be seen by the following letter, they had no alternative but to put in the foundation, which consisted of a small amount of rough rubble masonry. Nothing has been done upon the work within a year.

(Copy.)

[Incorporated June, 1856.]

CORLISS STEAM ENGINE COMPANY, }
 George H. Corliss, Treasurer, }
 Providence, R. I., 11th May, 1872. }

To Messrs. Moses B. Lockwood, Charles E. Carpenter, Joseph J. Cooke, Water Commissioners:

Gentlemen:—My pending contract for a steam pumping apparatus for the city of Providence, was undertaken with a clear understanding that it was to be used in connection with a “Standing Pipe” for 120 feet “head.” Mr. Shedd has proposed to me the substitution of an *Air Chamber* in place of a standing pipe.

Now this is to say that I do not deem either the standing pipe or the air chamber necessary to the proper working of my system, and shall be content to *try* the apparatus without either of the said appliances, but I do not waive my right to the benefits of the standing pipe, if, *after trial*, I should be satisfied that it is necessary to the successful working of my apparatus.

Very respectfully yours,

GEORGE H. CORLISS.

Sixth:—As to “*what amount has been paid for marble used in construction, and where located, and what sums have been expended for foreign granite, and where it was obtained.*”

The only marble used in the construction of the works is a slab for a wash bowl at Hope Engine House, the cost of which was fifteen dollars. No foreign granite whatever has been used.

Seventh:—As to “*the number of employes in the Engineering Department,*” etc.

The force in both water and sewer departments, the capacities in which they severally act, and their rates of compensation, are as follows:

WATER WORKS AND SEWERS.

A chief engineer at a salary of \$8,000 per annum.

An assistant engineer, who has general charge of the business of the office, verifies bills and estimates requiring the approval of the chief engineer, and pays off the yard and service pipe employes and all laborers on sewers constructed by the day. Salary, \$3,000 per annum.

A clerk at \$1,000 per annum.

A copyist at \$1.25 per day.

WATER WORKS.

An assistant engineer in charge of operations at Pettaconset Pumping Station, Hope Reservoir and Pumping Station, and Sockanisset Reservoir

Salary, \$3,000 per annum, and an extra allowance of \$85 per month while attending to his duties at both stations.

An assistant engineer, resident at Pettaconset Pumping Station, at \$1,200 per annum and rent of house.

Two students at same place, at \$300 each per annum.

An axeman at same place, at \$2.00 per day.

Two assistant engineers at Hope Reservoir, one each at \$1,200 and \$1,000 per annum.

Two students, at same place, at \$400 each per annum.

A time-keeper and handy-man, at same place, at \$3.00 per day.

An assistant engineer on distribution, at \$1,200 per annum.

Two students on same work, one each at \$500 and \$400 per annum.

An assistant engineer in the office, on plans, service and miscellaneous work, at \$1,000 per annum.

A mechanical engineer, at \$200 per month.

A service-pipe engineer, at \$1,000 per annum.

SEWERS.

An assistant engineer in charge of designs, plans, records and general office business of sewers and private drain connections, at a salary of \$2,500 per annum.

An assistant engineer in general charge of construction (field work) at \$2,500 per annum.

Two assistant engineers on construction, one each at \$1,200 and \$1,000 per annum.

Two assistant engineers on field and office work, one at \$1,000, and one working afternoons only at \$500 per annum.

Two students at \$500 each, and one at \$400 per annum.

One handy-man (field work) at \$2.00 per day.

Two draughtsmen and general assistants, at \$1.50 per day each.

One engineer of private drain connections, at \$100 per month.

One temporary assistant to above, at \$3 per day.

Two clerks, one at \$1,000 per annum and one at \$2.25 per day.

Eighth:—As to “*the accessibility of all contracts*,” etc.

The Commissioners do not remember that any case has ever occurred in which a citizen has been denied opportunity to examine a contract *after* its execution. An examination of records has never been denied excepting when containing a record of proposals for furnishing work and materials, the *contract* for doing which had not been executed. The “Ordinance in Relation to Water Commissioners and Water Works,” approved September 20, 1869, provides that “the contents of no proposal shall be made known to any person not a member of the commission until after a contract shall have been made.” While, therefore, pleasure is taken in affording information to parties interested in the work, it is

not conceded that the transaction of business in the several departments should be impeded by improper demands upon the time of the Commissioners or their employes.

Ninth:—As to “*the comparative merits and cost of Scotch and other pipes,*” etc.

The essential points of a good sewer pipe are, strength to withstand external pressure; the ability to resist the chemical action of sewage acids and gases upon its inner surface, and of the earth in which it may be imbedded; true shape and interior smoothness.

The pipe mainly in use by this department is the Scotch vitrified stone-ware pipe, the excellence and durability of which is undisputed. We have also used the vitrified pipe of several different American manufacturers, which usually have less strength, and also cost less (the best of them by from six to nine cents per foot for twelve-inch pipe, and nine to fifteen cents per foot for fifteen-inch pipe). This difference in cost is a small percentage on the completed sewer, as the cost of excavating, backfilling, laying, paving, etc., is the same, whatever the pipe used. With one or two exceptions, the American makers use the slip-glaze, which allows the use of poorer clay and less complete burning than is necessary for pipe of a reliable character. The salt-glazed pipe must be of good clay and thoroughly burned to make a perfect glaze, and, at the same time, a sound pipe of true form. We have never laid cement pipe, so-called, made of cement and sand, for reasons which appear in this statement.

As, according to the tests of time and science and the judgment of the best engineers of this country, well made vitrified stone-ware or clay pipes, and in an eminent degree, the Scotch, possess all the requisites for sewerage uses, the question as to comparative merits may best be answered by stating the objectionable features of cement pipe.

Weakness.—When our present Point street sewer was built, in 1872, a line of cement pipes was taken up that had been

laid about a year. The contractor was to have these pipes, but many of them would not hold together to be taken out, and the attempt to save them was abandoned.

In excavating for a new sewer in Friendship street, in this city, early last month, a line of six-inch cement drain pipes was taken out, some of which were examined and found to be so soft that a pick-point lightly struck on the top would penetrate it half an inch, and the bottom was not as hard as some kinds of dry, unbaked clay. It is not known when they were laid.

The city surveyor of Hartford, in 1872, says: "I have long been convinced of their utter worthlessness, as now made, and our experience in taking up several lately has borne the strongest proof of the correctness of my opinion. We have had occasion to remove quite a number of small pieces, one of which had only been laid a little more than a year, and the others a longer time, and in every case we have found them either smashed in the ground or else so far gone that with the greatest care they could not be removed from the trench."

In Taunton, a portion of a cement pipe sewer, through which only clear water flowed, was uncovered for examination, to determine the question as to further use of that kind of pipe. It was found to be honey-combed and in so weak a condition that brick had to be substituted.

John P. Culver, chief engineer, Board of Public Works, of Jersey City, says: "Cement pipe never will answer a safe purpose until it can be manufactured so as not to become disintegrated after being laid in the trench and covered. I have known a sewer to cave in built of it, and make a most disagreeable state of affairs from the fact of not knowing to what extent the break extended."

The city surveyor of Newark, N. J., has used them and finds they break easily.

Large cement pipes have been found broken into several pieces in Indianapolis.

The city engineer of Springfield, Ill., says that they are

seldom of uniform texture and are very easily broken; don't consider them safe or durable, while the vitrified pipe is as lasting as time.

While it is true that some cement pipes may, and occasionally do, prove durable under the service to which they have been subjected, there is always an uncertainty attending their use, which cannot be said of the Scotch pipe, and perhaps some American brands of vitrified pipe.

E. S. Chesbrough, city engineer of Chicago, and the highest authority on the subject of sewerage in this country, says that while some cement pipes have laid twenty years, and are still in good condition, others have failed in less than three years; and further, that it is very difficult, if not impossible, to be certain with regard to the quality of a cement pipe, while it is not so with regard to hard-burnt clay. He says in conclusion: "Cement pipes have been slowly disintegrated by certain gases and acids emptied into them. Some very striking instances of this kind occurred in San Francisco, where urine from privies was discharged into the cement pipes. Nothing of this kind has ever occurred, so far as I can learn, with well-burnt pipes. My opinion is that hard burnt or vitrified clay pipe should be preferred for sewerage purposes to cement pipe, because of the much greater certainty of getting a good article of the former than of the latter; and in this respect I have the concurrence of several distinguished members of my profession, who have come to their conclusion on the subject after years of observation and experience."

City engineer Smedley, of Philadelphia, says of cement pipe, that although somewhat cheaper than vitrified pipe, there is so much uncertainty in them that he would not be willing to risk their general introduction. "Cases have been reported to me of cement pipes where they have all had to be taken up on account of their deterioration."

The city engineer of Patterson, N. J., does not believe care is taken to have the cement pipes of uniform texture, and that if sufficient water is used to make the mass homo-

geneous, the time required to have the pipes properly made and the cement well set and seasoned, would make the cost of cement pipe equal to vitrified.

N. Henry Crafts, formerly city engineer of Boston, says he regards cement pipe as worthless unless made of the best materials, and even then it is not as good as the vitrified—would use the latter notwithstanding the difference in cost.

The superintendent of sewers in Boston says that one of the worst features of the use of cement pipe is the uncertainty of its quality,—no sample test being possible.

The city engineer of Pittsburgh is of the opinion that if the proper quality of materials is used, and their thorough manipulation and proper “setting” is secured, cement pipe *may* stand, otherwise the most unsatisfactory results will be obtained. He would not like to risk it on any extensive work.

The city surveyor of New Haven, where cement pipe has been somewhat extensively used, confesses to a feeling of uneasiness, and thinks the time may come when it will be found that the experiment was tried on too large a scale.

Susceptibility to Chemical Action.—About five years ago, Professor S. W. Johnson, of Yale College, reported as follows to the mayor of New Haven, on the comparative merits of salt-glazed Scotch pipe and cement pipe: “The cement pipe becomes lined, indeed, with a greasy coating which, doubtless, would hinder the subsequent action of acid, but the solubility of the cement is nevertheless a most serious objection in a sewer pipe, which must be laid down and repaired at heavy cost, and which ought, therefore, to be made of the most durable materials. I have also examined the salt-glazed stoneware pipes. These appear to unite every quality of material requisite for a good sewer pipe.

“They are exceedingly hard and fine in texture, and are well coated on both sides with the salt-glazing, which is nearly the same thing as a coating of glass, and is as nearly insoluble and indestructible by acid and alkali as anything which the arts produce that can be employed in sewer pipes.

“The salt glazed pipes deserve the preference, especially as their expense is not much greater than that of the cement pipes.”

In Philadelphia, in 1871, Thomas Shaw, a well known engineer, immersed separately in the strongest sulphuric acid, two samples each of Scotch and American vitrified clay and cement pipe. They remained immersed about three months, when, on examination, the Scotch and American vitrified pipe were found to be in no way affected, while the cement pipe showed the disintegrating effects of the acid in its corroded surface, and in the separated particles of cement and sand with which the bottom of the vessel was thickly covered.

Charles A. Putnam, a civil engineer of Salem, Mass., reports the following case which came under his notice: In 1869, some cement pipe drains owned by the Naumkeag Steam Cotton Company, and through which privy sewage was discharged, were uncovered to make connections, when they were found to be in very bad condition, the bottom of the pipes being in about as soft a state as the matter flowing through them, and would fall out when the pipes were lifted from their beds. The pipes leading from the houses were in a better condition and are still in use. These pipes were made under the Knight patent, and were laid in 1865-6.

Cement pipes have been condemned in New York City, Chicago, Cincinnati, Toledo, Washington, Minneapolis, Little Rock and other localities, for the specific reason that they will sooner or later become disintegrated by the action of sewage acids, gases, etc.

In Washington, cement pipes, uncovered by a change of grade, were found to be in such a state of decomposition that they could not be taken up whole.

In Jersey City, in 1872, quite a number of cement pipes were uncovered, all of which were more or less disintegrated on the outside.

In Rochester, cement pipes that had been down only one year were found to be unfit to relay.

Several cases of the destruction of cement pipes by acids,

urine and house drainage, have come to the knowledge of our chief engineer.

Less than one-fourth of our large cities use cement pipes. Some that formerly did so have abandoned the practice; among them Jersey City, St. Louis, Hartford, Erie, Toledo, Baltimore and Richmond.

Besides these, the following cities do not use cement pipes: Washington, which, in 1872, laid seventy miles of pipes, nearly one-half of which (and the most satisfactory portion) were Scotch; Paterson, N. J., where the use of Scotch is required by ordinance; Philadelphia, New York, Pittsburgh, Chicago, Columbus, Cincinnati, Alleghany, Lancaster, Springfield, Ill., Minneapolis, Fort Wayne, Little Rock, Lawrence, Kan., Augusta, Lynn, and others.

It is understood that the following cities use cement pipe: Brooklyn, Portland, Cambridge, New Haven (less than formerly), Newburg, Buffalo, Harrisburg, Cleveland and the Newark Aqueduct Board. Boston has used all kinds, but now favors vitrified.

The present cost of Scotch pipes, delivered in this city, is 74 cents per foot for 12-inch, and \$1.15 per foot for 15-inch.

The cost for American vitrified pipes varies from 52 cents to 68 cents per foot for 12-inch, and 92 cents to \$1.06 per foot for 15-inch, the smaller prices being conditioned on the purchase of large quantities.

The original bill of some 12-inch cement pipe bought in this city for the purpose of making tests, gave the price as 60 cents per foot net, but a new bill at 50 cents per foot net was afterwards sent in.

In the purchase of Scotch and American vitrified pipes, we have dealt with seven different parties—four in New York, two in Boston and one in New Haven.

Of the total length of sewers constructed during the last four years, sixty-six per cent. is of the Scotch and American vitrified pipes, sixty-two per cent. being Scotch: the remaining thirty-four per cent. is of brick. Included in the total amount laid are the catch-basin connections, which somewhat increase the proportion of pipe to brick sewers.

Tenth.—As to “*the depths and sizes of our sewers, as compared with the larger cities of this country.*”

Until recently the standard depth for our sewers,—measured to the inside crown of the arch,—has been eight and a half feet below the level of the curbstone. This depth was adopted in concession to popular prejudice on the subject, but recent experience in this city, and further information as to the experience of other cities, have induced the commissioners to change the standard depth to ten feet, which is believed to be none too great for the most efficient and economical results. In some parts of the city it is impossible to obtain this depth,—nor, in cases, even half of it,—on account of the height of the tide, it being in no instance allowed to construct the sewer so as to be continually under water, nor can this standard depth be uniformly adhered to in other parts of the city, as a proper grade, or fall, must be maintained, however irregular the surface of the ground: and in streets like Congdon and Benefit, the depth should be such as to admit of a proper fall for house drains from estates on the lower side of the street, that on account of their location, can have no other means of drainage. In Congdon and Benefit streets the sewers are sixteen feet deep, but there are cellars now built on both those streets that are too deep to be drained into the new sewers. A less depth than the standard adopted, while it would answer for surface drainage, would generally render the work of little value for house sewerage or for that very important service of lowering the stagnant water about the foundations of buildings.

In New York, the general grade of street sewers is thirteen feet below the level of the curb.

In Brooklyn, the present practice is to lay the brick sewer invert thirteen feet and the pipe sewer invert twelve feet below grade of street.

(The measurements for depth are generally given to the invert.)

In Boston, the ruling depth for suburban sewers is about nine feet, and for business purposes twelve feet, or ten feet clear, to the highest water line in the sewer.

In Jersey city it is the rule, where possible, to arrange the water run of sewers twelve feet below curb grade.

In Newark, N. J., the sewers generally are about thirteen feet below the street grades, that depth being considered sufficient for ordinary cellars. Some of the sewers are much deeper, and many, *on low ground*, are of less depth.

In Philadelphia, the depths of the sewers are such that the bottom of the house-connection pipe must enter the sewer, (usually at the springing line of the arch), at a depth of eight and one-half feet below curb level, which would bring the bottom of a three feet circular sewer ten feet below the curb level.

In Cleveland, the *minimum* depth of main sewers is twenty feet, which, on account of the very uneven topography of that city, necessarily carries some portions of the sewer much deeper; and for branch sewers, twelve feet is the minimum depth, unless it be in exceptional cases.

In Cincinnati, the general depth of brick or main sewers is fifteen feet, and of pipe or lateral sewers, thirteen feet.

In Chicago, twelve feet to the bottom of the sewer, and sometimes more, is considered very desirable, but they are often compelled to make nine feet, and even less, answer, in low streets.

In St. Louis, on account of the topography of the city, the trunk sewers vary from ten to sixty feet in depth. The main sewers or channels of drainage, into which the lateral sewers discharge, are generally sixteen feet deep; and the district or lateral sewers about twelve feet. Greater depths are now demanded than in former years.

Information in regard to the depth of sewers in other countries, is contained in the report on sewerage made to the board of aldermen in February of this year.

The proportion of our small sewers (twelve and fifteen inches in diameter) to the total length of all sizes constructed, is sixty-three per cent.

In Brooklyn, these sizes amount to seventy and one-half per cent., of which, according to the latest reports by which a comparison can now be made, something less than one half are of cement pipes.

The later New York sewer reports fail to give total construction by sizes. Previous to 1865 pipe sewers were not laid in that city, and of course the proportion of large sewers was considerable. By the report for 1865 it appears that of the length of sewers planned for eight drainage districts, eighty-three per cent. was to be of twelve to eighteen inch vitrified stoneware pipe. In the five years ending with 1872, sixty-seven per cent. of the total length of sewers built in New York was of pipe. The former per centage, it will be seen, (and probably the latter) include eighteen inch pipe, which, in Providence, amounts to only a fraction over one per cent. of the total length laid.

Late Boston reports do not give summaries of all sewers laid; but of total length constructed during the years 1872 and 1873, the proportion of twelve and fifteen inch was forty-eight and two thirds per cent.

In Chicago, the proportionate length of twelve and fifteen-inch sewers, is thirty-three and two-thirds per cent; but on account of the flatness of the territory, and the necessarily slight grades of the sewers, much larger sectional areas are required than in a city like Providence, where the grades are steeper, and smaller pipes have the same capacity, and will do equally efficient service as larger ones in the former locality.

In Worcester, the proportionate length of sewers, fifteen inches and smaller, including 2,233 feet of nine inch, is forty-nine and one third per cent.

Eleventh:—As to “*the depths of our sewer outlets, with reference to the tides; and the cases of damage, if any, resulting from the overflow of tide water from the sewers into the basements of buildings; and, if any, the cause of such damage, and the proper remedy therefor.*”

With two exceptions the bottoms of these outlets are one foot or more above low tide, and are therefore entirely emptied of tide water twice in twenty-four hours.

The exceptional cases are those of Dorrance street, where the large size of the sewer and the flat grade of the street made

it necessary to put the bottom of the outlet only six inches above low tide ; and the intercepting sewer which is a little less than a foot above. The larger outlets are never entirely submerged by ordinary high tides.

We are not aware that the tide will rise any higher, with reference to cellars, in deep sewers than in shallow ones.

Only one case of injury resulting from the overflow of tide water from a sewer into the basement of a building has come to our knowledge. In that case, we are informed that an occupant of the premises propped open a tide valve with a stick, designing to let the water out faster, and left the valve so for the tide to flow through into the cellar on its next rise. The proper remedy for such injury is to leave sticks out of the valves.

No claims for damages can lie against the city on account of injury by reason of private sewer connections, as each owner of an estate connecting with a sewer is required to sign an application before a permit to connect is issued, containing the following clause :

“And the undersigned further agrees that no claim for damages which may be occasioned to such estate, or any property thereon, in any manner, by the construction, use or existence of such drain or connection, shall be made against the city.”

Twelfth :—As to “*the amount of deposit in the sewers,*” etc.

From November 17th, 1873, (when the present superintendent of cleaning began service,) to September 30th, 1874, 7,400 feet of the 57,875 feet of the new sewers under his charge required cleaning ; and the amount of deposit taken out was 4,518 cubic feet, or less than eight per cent. of a cubic foot per running foot of the total length of sewers. In nearly every case, those portions of the sewers below high water mark are, and have been from the first, kept entirely clean by the action of the tides.

During the same time, 2725 feet of the 37,500 feet of the old drains required cleaning, and the amount of deposit taken out was 8,081 cubic feet, or about twenty-one and a half per cent. of a cubic foot per running foot of the total length of

drains. Those portions of the old drains requiring to be cleaned, were in most cases full or nearly so. A general cleaning of old sewers had previously been made.

It will be seen that the proportion of deposit in the new sewers to that in the old drains was, per foot, as 8 to 21.

A large proportion of the cleaning of the new sewers has been made necessary by deposits left in them during their construction ; or during or immediately after the construction of sewers discharging into them. This was *entirely* the case in North Main street, where eighteen days and four hours labor were spent on the upper end of the sewer this season, which is the longest time that has been given to any one sewer. Earth is sometimes carried into the sewers during the construction of private drains.

The new sewers receive their surface drainage through catch-basins at the sides of the streets, by means of which catch-basins as much as possible of solid matter is kept out of the sewers. In the case of the old drains, there are some small catch-basins, but generally there are only chutes of no retaining capacity. In the old drains, however, there are large chambers where a portion of the deposits, which have passed through the catches or chutes, settles.

The deposits taken from the catch-basins of the new sewers, amount to 48,091 cubic feet.

The deposits taken from the sand-catchers of the old drains, amount to 4,471 cubic feet, and from the chambers of the old drains, 21,269 cubic feet have been taken, a portion of which would, but for them, have remained as deposit in the sewers, and the balance been discharged into the harbor.

Thirteenth ;—As to “ *the method employed for cleaning the sewers,*” etc.

The method mainly relied upon for cleaning the sewers, is flushing with water from the hydrants. The rush of water carries the accumulations along to the manholes, where they are stopped by temporary dams and taken out. Sewers of sufficient size for laborers to enter are either flushed or cleaned

by the use of a shovel adapted to the purpose. In five streets where sand had been washed into the sewers from new sewer trenches, or on account of extraordinary circumstances, an apparatus designed to be dragged through the sewers, has been used to gather the material. The total length of time during which this was employed on the five streets was about fourteen days. This apparatus has not been used on North Main street for more than a year. The sewers rarely need cleaning, except where earth has been washed in from other new work.

Fourteenth: As to "*the condition and capacity of the stone sewers taken up, their total length, with the sizes and kinds of sewers substituted therefor.*"

This question seems to imply a right of discretion on the part of the Commissioners, as to whether or not to take up old stone drains. The Commissioners never had such right, but have been positively directed in each case by the Board of Aldermen, or by the City Council, to construct new sewers where the old ones existed. The order itself indicates dissatisfaction with the old stone drains, and the Commissioners, in putting in new sewers, have built such as they believed the locality demanded, quite independent of the size or depth of the old drains. When the construction of sewers under the present system was begun, the work was ordered by the Board of Aldermen, and for more than two years it was the practice to submit plans to the Board, giving sizes and locations of the proposed sewers, before the work was ordered by the Board. The system was thus established and endorsed by the city government, and at the time when the mode of ordering sewers was changed, an elaborate report upon the sewerage system was, by order of the Board of Aldermen, published and distributed to members of the government and to citizens generally. The Commissioners have never received any intimation, from either branch of the city government, that the plans are not fully approved, and after such long and public notice of their character, it seems proper to conclude that the system is endorsed in every particular by the City Council.

The following table gives the comparison called for as far as practicable :

OLD DRAINS TAKEN UP OR SUPERSEDED.

STREETS.	SIZES.	LENGTHS.	CONDITION.	SIZES SUBSTITUTED.
Angell....	2'6" x 1'8"	200 ft.	Fair.	12-inch pipe,
Thayer ..	20" x 30" brick	60	Good.	22" circular brick.
	15" pipe.	440	Good.	22" circular brick.
Star	2'6" x 1'8"	315	Fair.	15-inch pipe.
Pearl....	3'8" x 3'4"	2,211	Good.	505 ft. of 38" x 57" brick.
				1,198 ft. of 36" x 54" brick.
				508 ft. of 24" x 36" brick.
Washington ...	3'6" x 3'0"	400	Fair.	22" circular brick.
Dorrance	4'0" x 3'6"	1,120	Good.	66" circular brick.
Westminster...	4'0" x 3'6"	1,978	Good.	659 ft. of 22" brick.
				434 ft. of 18" pipe.
				307 ft. of 15" pipe.
				578 ft. of 12" pipe.
Fountain	4'6" x 4'0"	25	Good.	12" pipe.
Brook.....	4'0" x 4'0"	1,680	Fair.	380 ft. of 32" x 48" brick.
				1,300 ft. of 28" x 42" brick.
Wickenden	4'0" x 4'0"	160	Fair.	20" circular brick.
Ship.	2'6" x 1'3"	440	Fair.	12" pipe.

A part of the old drain in Pearl street, (six hundred feet,) was left in the ground, but is no longer used.

The new brick sewers, not specified as circular, are egg-shaped.

The old sewer in Thayer street was ordered to be taken up, because of its insufficient depth, and the new one was laid six to seven feet deeper.

The old drain in Westminster street contained six inches to three feet in depth of very offensive matter. Those in Washington, Pearl, Dorrance and Wickenden streets, contained some mud, and the one in Ship street about three inches of sand.

The capacity of stone sewers, as compared with pipe or brick, cannot be given by sizes ; the rate of fall and the *smoothness* of the conduit enter very largely into the question.

Experiments have proved that with the same size and fall, a rough conduit, (smooth, however, as compared with a stone drain) requires twice the head or force to discharge a given quantity of water that is required by a smooth one.

Fifteenth:—As to “*whether any sewers have been constructed which were not ordered by the City Council,*” etc.

There has been no case of the construction of a sewer where one was not ordered by the proper branch or branches of the city government.

It has been the practice from the beginning of the work on sewers by this commission, whether acting as Commissioners or as a committee of the Board of Aldermen, to run spurs from the main line under construction to the lateral streets, so that when sewers shall be laid in those streets, the work can be connected without disturbing the street in which the main is laid. Such spurs were always represented in finished plans furnished to the Board of Aldermen.

Sixteenth:—As to “*the kind of pipe which parties connecting with sewers are required to use.*”

There has as yet, been no restriction upon the kind of pipes used by such parties, except that it shall be reasonably free from liability to destruction, where it would injure the public sewers, and especially where it is located within the public highway. Parties have selected such pipe answering this requirement as they chose, usually that of American manufacture, and we are not aware that any Scotch pipe has been used for the purpose in the city.

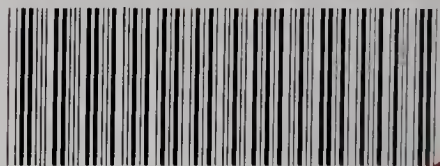
Question by Alderman Clarke :—“What motives influenced the Water Commissioners to place a Cornish engine at Pettaconset, instead of a Worthington?”

*Answer :—*In the quarterly report of the commissioners, April 1, 1871, in speaking of the Worthington engine, they say : “The height of suction made necessary by our plans in order to be secure from injury by freshets in the Pawtuxet, (at least 12 feet,) added to the depth of the natural filter basin, precludes its permanent use at Pettaconset, even if there was no doubt otherwise of its superiority to the Cornish.”

The Commissioners now add that the much larger duty which they believe that the Cornish engine, constructed in accordance with their plans, will perform, will result in great economy in use, at any rate when the demand for water shall be fairly proportioned to its capacity.

JOSEPH J. COOKE,	} Board of Water	
CHAS. E. CARPENTER,		Commissioners.
WILLIAM CORLISS,		

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